

September 21, 2001

MEMORANDUM FOR: Clifton S. Middleton
Project Director, Survey Section B

FROM: Charles W. Challstrom
Director, National Geodetic Survey

SUBJECT: INSTRUCTIONS: Wisconsin Height
Modernization, Phase 3 - Primary GPS
Network
Task Number: 8K6D30

GENERAL:

The National Geodetic Survey (NGS), in accordance with the National Height Modernization Initiative, will advise and assist the Wisconsin Department of Transportation (WisDOT) in their effort to establish a grid of three-dimensional survey control stations in the Fox Valley area of Wisconsin around Lake Winnebago. Some benefits associated with the National Height Modernization project are:

- * Replace labor-intensive, high-cost leveling procedures with new cost-efficient GPS technology.
- * Decreased survey costs associated with flood plain and other mapping and GIS activities.
- * Increased efficiency and accuracy of water delivery and drainage systems.
- * Improved aircraft navigational aids and safer approach and landing procedures.
- * Advanced surface transportation control and monitoring.
- * Highly efficient fertilizer and pesticide spreading, resulting in reduced run-off water pollution.
- * More accurate modeling of storm surge and pollution trajectories.
- * Improved disaster preparedness and earthquake detection.

Additional information regarding the National Height Modernization Initiative is available at the following web site:

http://www.ngs.noaa.gov/initiatives/height_modernization.shtml

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PURPOSE:

Under the Agreement between NOS and the State of Wisconsin, signed 11/27/2000, NGS will provide WisDOT with a team of Height Modernization Specialists (HMS). The HMS will coordinate and assist in providing technical advice and assistance to the State. NGS will partner with WisDOT in observing the Primary Base Stations for the Wisconsin Height Modernization, Phase 3, which includes approximately 26 stations.

SPECIFICATIONS:

Project requirements for the observations are to ensure 2-centimeter local accuracy in the horizontal component, as well as 2-centimeter local accuracy for the ellipsoid heights.

Data from the National CORS in the region are to be used in the processing. That includes Milwaukee 1 CORS ARP (MIL1). Positions and data for the National CORS are available from the NGS web site.

General specifications for the project are as follows. At each site, three sessions of 5-1/2 hours duration each shall be observed. The observing scheme shall be arranged so that the start time of one of the 5-1/2 hour sessions is at least 4 hours different from the other two.

In general, station occupation and observing procedures must be carried out according to appropriate sections of the "NGS Operations Handbook" and the current applicable receiver field manuals. Data formats and digital file definitions are given in "Input Formats and Specifications of the National Geodetic Survey Data Base," Volume I. Horizontal Control Data, Federal Geodetic Control Subcommittee, September 1994, revised and reprinted November 1998. Success in meeting the accuracy standards will be based on repeatability of measurements and adjustment residuals.

General specifications for the project are given in "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques," Version 5.0: dated May 11, 1988, reprinted with corrections August 1, 1989. Specific project criteria and deviations from the general specifications are given in the following sections.

Project Network - A list (Table 1) and sketch of stations involved in this project will be provided.

Data Acquisition - Data collection must be accomplished as specified in the appropriate dual-frequency receiver field manuals in the compressed mode at a 15-second epoch collection interval. The GPS receivers must be dual-frequency and full-wavelength. Track satellites down to a 10-degree elevation angle.

The 5-1/2 hour sessions are to begin at two observing windows at least 4 hours apart. Continuous and simultaneous tracking is required.

Record weather data just before, immediately after, and at the mid-point of each session. Meteorological data shall also be collected immediately after an obvious weather front passes during a session and immediately before it passes, if possible. Pressure and relative humidity measurements must be made near and at about the height of the GPS antenna phase center. Indicate in the log the location of the barometer and psychrometer.

Survey operations shall be conducted with due regard to the safety of personnel and equipment.

Vector Computations - Processing will be done by WisDOT under the direction of Ms. Lucy Hall, N/NGS22. Data management, quality review of collected data, and final vector processing for the survey will be accomplished using PAGES. Vectors shall be computed in the International Earth Rotation Service Terrestrial Reference Frame (ITRF) system, using the most current epoch and precise IGS ephemerides. Use 30-second epoch intervals for data processing. Monument positions will be used for CORS when available, otherwise, antenna reference point (ARP) positions will be used.

The data will be processed in 24-hour sessions (or slightly longer if the observation session crosses 0000 UTC) in order to utilize the 24-hour data sets collected at the nearby CORS. The "fixed baseline" option in PAGES will be used to compute direct baselines between the CORS. The "fixed baseline" scheme will depend on the location and reliability of the CORS used in this project.

For stations where weather data are not available, or are suspect, predicted values computed in PAGES based on the station's latitude, height above mean sea level, and time and day of year will be used. Use 15 degrees as the cutoff elevation angle in data processing. A cutoff angle of 10 degrees may be used when necessary to improve results.

The type of final solution, L1 versus ion-free, will depend on the length of the vectors. For vectors which are less than 10 km in length, the final reduction will consist of a L1 fixed solution. These vectors will be computed in a separate processing session from the longer vectors computed in an ion-free solution.

In general, vectors greater than 10 km in length are to be computed in an ion-free fixed, or partially-fixed, solution. In all cases, integer ambiguities will be fixed for each vector whenever possible.

The quality of collected data shall be determined from the plots generated from PAGES, by analysis of repeated vectors and/or comparison of station positions, and free adjustment residuals and/or loop misclosures. In addition, a constrained adjustment constraining the CORS will be performed.

WisDOT will perform all quality checks for conformance with NGS format standards such as executing software programs COMPGB, OBSCHK, and OBSDES. The final ITRF vectors will be assessed and transformed to the NAD 83 coordinate system using program ADJUST.

The data and results will be submitted to the Observation and Analysis Division. All B-files and G-files must be complete, including *25* and *27* records.

Station Descriptions - Station descriptions and recovery notes will be done by WisDOT. Station recovery notes must be submitted in computer-readable form using WDDPROC software. Include the name, address, and, if public ownership, the telephone number of the responsible party. Do not include the telephone numbers of private property owners.

Special Requirements - Antenna set-up is critical to the success of this project. Fixed-height tripods are preferred for all receivers. The plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbing is

performed. They must be shaded for 3 minutes before checking and/or re-plumbing. Also, the perpendicularity of the poles must be checked at the beginning of the project and any other time there is suspicion of a problem.

When a fixed-height tripod is not used, the height of the antenna must be carefully measured to prevent station set-up blunders from occurring. Tribrachs used for these set-ups must be checked and adjusted when necessary. Totally independent measurements of the antenna height above the mark in both metric and English units must be made before and after each session. Someone other than the observer must check the measurement computations by carefully comparing measurements and then entering his/her initials on the log.

Some GPS antennas have detachable ground planes and radomes. In order to help identify what exactly was used at a particular site, it would be useful to have a snapshot of the setup. All observers should take a photograph of the setup, if possible, with a close-up of the antenna as viewed from the side.

In addition, digital photographs of each survey mark are required. See "Requirements for Digital Photographs of Survey Marks & CORS Antennas," Version 5, for specific information.

Also, a rubbing of the stamping of the mark must be made at each visit to a station. If it is impossible to make a rubbing of the mark, a plan sketch of the mark must be substituted, accurately recording all markings.

Also, for each station visited, a visibility obstruction diagram must be prepared and the TO-REACH description carefully checked for errors or omissions.

Lastly, the following must be recorded at each occupation of a station:

- (1) receiver manufacturer,
- (2) antenna manufacturer,
- (3) receiver model number (part number),
- (4) antenna model number (part number),
- (5) the complete serial number of the receiver, and
- (6) the complete serial number of the antenna.

Success of this project requires that the highest quality GPS data be collected. Therefore, during each station occupation, the operators shall carefully monitor the operation of the receivers. Any irregularities in the data due to equipment malfunction, DOD adjustment of the satellite orbit, obstructions, etc., must be reported to the Project Development Branch, N/NGS21, as soon as possible and noted on the observing log. If the quality of observations for an observing session is questionable, notify the Project Development Branch immediately.

The survey team shall not depart the project area until they have quality reviewed all data and advised N/NGS41.

GPS DATA:

Visibility tables and plots of the present satellite constellation for September 4, 2001, have been reviewed and two observing windows selected. For operational use, current data must be generated with Trimble mission planning software or from program SATMAP.

A project report and the data listed in Annex L of "Input Formats and Specifications of the NGS Data Base" and in the attached addendum for the adjustment portion of the project must be transmitted. Any data considered suspect as to quality in achieving accuracy standards should be sent via FedEx immediately for office review. Backup of transmitted data must be held until notified by the Project Development Branch, N/NGS22.

The data set collected during the project shall be named "wiht091d.887". All records in connection with this project shall be titled "Wisconsin Height Modernization, Phase 3 - Primary GPS Network". The project number (accession number) is GPS-1563.

LIAISON:

Liaison must be maintained with designated offices at the National Geodetic Survey headquarters located at:

1315 East-West Highway
Silver Spring, Maryland 20910-3282

Questions and problems concerning survey field operations should be directed to:

William T. McLemore
Chief, Field Operations Branch
Observation and Analysis Division
N/NGS41, SSMC III, Station 8564
Telephone: 301-713-3215, ext. 117
Fax: 301-713-4327
e-Mail: bill.mclemore@noaa.gov

Questions and problems concerning adjustment processing should be directed to:

Maralyn L. Vorhauer
Observation and Analysis Division
N/NGS4, SSMC III, Station 8562
Telephone: 301-713-3176, ext. 104
Fax: 301-713-4327
e-Mail: maralyn@ngs.noaa.gov

Questions and problems concerning vector processing should be directed to:

Lucy Hall
GPS Branch, Spatial Reference System Division
N/NGS22, SSMC III, Station 8823
Telephone: 301-713-3208, ext. 153
Fax: 301-713-4324
e-Mail: lucy.hall@noaa.gov

Questions and problems concerning using CORS data in processing should be directed to:

Neil Weston
Geosciences Research Division
N/NGS6, SSMC III, Station 9830
Telephone: 301-713-2847, ext. 202
Fax: 301-713-4475
e-Mail: nweston@ngs.noaa.gov

Questions and problems which could affect the technical adequacy of the project should be directed to:

Stephen J. Frakes (Douglas R. Hendrickson)
Chief, Project Development Branch

Spatial Reference System Division
N/NGS21, SSMC III, Station 8853
Telephone: 301-713-3194, ext. 111 (ext. 127)
Fax: 301-713-4316
e-Mail: steve@ngs.noaa.gov (dough@ngs.noaa.gov)

The WisDOT contact for the project is:

Darin Henkel
State Land Surveyor
WisDOT Surveying and Mapping, Room 5B
P.O. Box 7916
Madison, Wisconsin 53705
Telephone: 608-264-8710
e-Mail: darin.henkel@dot.state.wi.us

Names and telephone numbers of local contacts are given in the station description material.

ADDRESS:

Keep N/NGS41 informed of the party's physical address and telephone number at all times.

PUBLICITY:

See "NGS Operations Handbook," Section 1.4.1.

EXPENSES:

Expenses for this project will be charged to task number 8K6D30.

TRAVEL:

Travel and per diem are authorized in accordance with Federal Travel Regulations, Part 301-11, Per Diem Allowances. Current per diem rates were effective October 1, 2000.

ACKNOWLEDGMENT:

Please acknowledge receipt of these instructions in your Monthly Report.

cc: N/NGS - D. Zilkoski*
N/NGS - S. Misenheimer*
N/NGS1 - G. Mitchell
N/NGS11 - S. Cofer
N/NGS11 - W. Rindal
N/NGS11 - D. Moyer
N/NGS21 - S. Frakes
N/NGS21 - D. Hendrickson*
N/NGS22 - T. Soler
N/NGS22 - L. Hall
N/NGS3 - J. Bailey
N/NGS4 - E. Wade
N/NGS4 - M. Vorhauer
N/NGS4 - D. Hoar
N/NGS41 - W. McLemore
N/NGS5 - R. Snay
N/NGS6 - N. Weston
FGCS Members*
Darin Henkel, WisDOT Surveying and Mapping
Paul Hartzheim, WisDOT Surveying and Mapping

* first page only

**DATA TO BE SENT TO HEADQUARTERS RELATING TO
THE ADJUSTMENT PORTION OF
FBN/CBN PROJECTS**

Free adjustment in NAD 83 (UNIX run).

Plots of the free adjustment created by running "plotres_prompt.bsh" on a UNIX server. Plots require a printer that supports postscript. The output file (long.out) contains a list of residuals which may be sorted using the following commands:

```
vi long.out
:1,$ !sort +0.47 (sorts horizontal residuals)
:1,$ !sort +0.71 (sorts vertical residuals)
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(OPTIONAL) Constrained horizontal adjustment holding NGS CORS positions and ellipsoid heights.

Final combined Blue Book file (ASCII required) with *86* records (GEOID99).

Final description file (ASCII required.)

Final G-file (ASCII required.)

OBSCHK output.*

CHKDDESC output.*

OBSDES output.*

*Any errors or warning messages must be explained.